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APPLIED PHYSICS SOCIETY 37TH MEETING

JPRS-JST-91-004
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SCIENCE & TECHNOLOGY

JAPAN

APPLIED PHYSICS SOCIETY 37TH MEETING

906C7539 Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 pp 71-191

[Selected "extended abstracts" presented at the 37th Spring Meeting, 1990 of The Japan Society of Applied Physics and Related Societies, held 28-31 March 90 in Tokyo]

CONTENTS

Analysis of 3-Terminal Superconducting Device by Quasiparticle Injection

906C7539A Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 90

[Article by Y. Harada, N. Hirose, Y. Uzawa, and M. Sekine, the Graduate School of the Tokyo Institute of Technology]

[Text] In the previous meeting, we reported changes in the energy gap of quasiparticle injection type three-terminal superconducting devices during quasiparticle injection, using the introduced nonequilibrium GL equation.[1] This time, we calculated voltage-current characteristics using the obtained energy gap values. This report outlines the results. The figures below show voltage-current characteristics with respect to input (injector junction) and output (acceptor junction) where Nb was used for the three electrodes. When the load was R_L = 0.46Ω, the current gain was G_1 = 5.5 and the power gain was G_p = 2.9. Further, as shown in Figure (b), when the injector voltage was V_1 = 2.87 mV, a negative resistance region appeared in the vicinity of the acceptor voltage V_a = 1.8 mV.

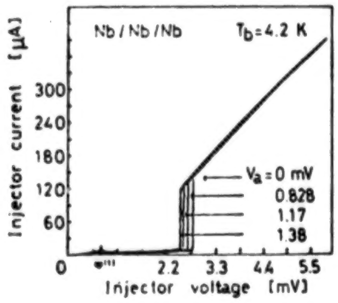


Figure (a). Input Characteristics (Injector junction)

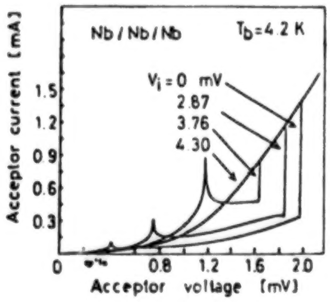


Figure (b). Output Characteristics (Acceptor junction)

Reference

1. Harada, et al., The 50th Science Lecture Meeting of the Japan Society of Applied Physics, 29 a-Q-6.

Josephson Stack Memory

906C7539B Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 94

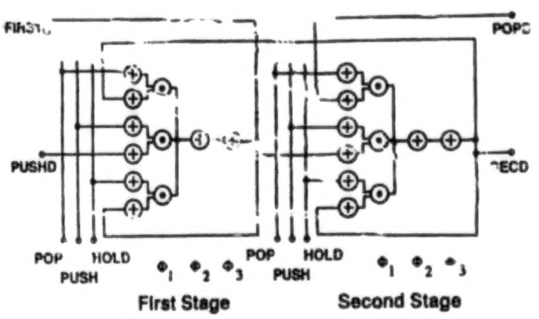
[Article by Atsuki Inoue, Seigo Kotani, Imamura Takeshi, and Shinya Hasuo, Fujitsu Ltd.]

[Text] 1. Preface

When instruction codes are supplied from ROMs to Josephson processors, addresses given to ROMs are generated by the address production part. The address production part generally supports sub-routine calls with consideration given to the instruction code memory use efficiency. This requires last-in-first-out type memories (stack memory) to retain the program counter values.

2. Design and Trial Manufacture

We composed a high-speed stack memory using our proposed three-phase alternating power supply system. This report outlines the results. The figure below shows a composition of a stack memory--using a shift register--with a capacity of two words and one bit. Data PUSH, POP, and HOLD are controlled by using a three-input multiplexer for the shift register input stage. The designed memory is six in bit width and the number of words is two. An MVTL gate of 1.5 μm in minimum junction dia. and the Nb system integrated circuit process were used for trial manufacture. Tests confirmed that all functions operate normally. High-speed tests also confirmed that all functions operate at a clock frequency of 1 GHz.



Acknowledgment: As a part of large-scale projects planned by the Agency of Industrial Science and Technology, the Ministry of International Trade and Industry, we conducted this trial manufacture under a contract awarded by the New Energy/Industrial Technology Comprehensive Development Organization.

Josephson 8b Multiplier

906C7539C Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 95

[Article by Seigo Kotani, Atsuki Inoue, Takeshi Iwamura, and Shinya Hasuo, Fujitsu Ltd.]

[Text] 1. Preface

Most high-speed signal processor LSIs are provided with a multiplier as a basic block. The 4-bit processor manufactured by us for trial is provided with a 4-bit multiplier.[1]

2. Design

We manufactured an 8-bit multiplier by expanding the bit width. As is the case with the previous trial manufacture, the newly manufactured multiplier is a parallel multiplier using the dual rail and ripple carry systems. The bit width was doubled; therefore, the circuit scale quadrupled and the number of critical path gate stages doubled. To reduce the multiplying time, the distance between gates was optimized and the total wiring length was controlled to 50 percent.

3. Trial Manufacture and Results of Measurements

The 8-bit multiplier was manufactured on a trial basis using MVTL gates whose minimum junction diameter is 1.5 μm and the Nb system integrated circuit process. The accuracy of the process and the uniformity of gate parameters were improved. The bias level, therefore, could be established on the higher side (90 percent → 95 percent). As a result of measurement, a multiplication time of 240 ps (average 5.3 ps/gate), which corresponds to 20 percent of the previous measurement, was obtained.

Acknowledgment: As a part of large-scale projects planned by the Agency of Industrial Science and Technology, the Ministry of International Trade and Industry, we carried out this trial manufacture under a contract awarded by the New Energy and Industrial Technology Comprehensive Development Organization.

Reference

1. Kotani, et al., Shingaku [phonetic] Technical Report, SCB88-61 1989.

Design, Fabrication, Characteristics of 4-Loop dc-SQUID Magnetometer

906C7539D Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 96

[Article by M. Nakanishi, S. Kiryu, and M. Koyanagi, Electrotechnical Laboratory]

[Text] 1. Preface

The floating capacity between coils causes dc-SQUID magnetometers to induce distortion of current-voltage characteristics and deterioration of noise characteristics during the operation of FLL. Therefore, we reduced the floating capacity of 4-loop dc-SQUID magnetometers. This report outlines the structure and characteristics of this magnetometer.

2. Structure

The SQUID loop of a 4-loop magnetometer, which is composed of a 50 μm-square coil (primary coil, inductance Ls = 91 pH) and three 1.8 mm-square coils (pickup coil, inductance Lp = 9.2 nH), is of a modified four-leaf clover type. A linear, modified coil was wired 10 μm away from the pickup coil. Each coil is located two-dimensionally and the floating capacity between coils is very small. The equivalent SQUID loop inductance is ($L_{eff} = L_sL_p/(3L_s + L_p) = 88$ pH $\sim L_s$). The characteristics of this magnetometer are controlled mainly by the primary coil. Most external magnetic flux is linked with a large pickup coil. The efficiency of transfer of magnetic flux to the primary coil is $3 L_s/L_p$.

3. Characteristics

The figure below shows magnetic flux-voltage characteristics during constant current biasing. Little distortion can be observed. For this device, $\beta = 2I_oL_s/\phi_o$ is 1.1. The white noise characteristics while the FLL is being operated is 2.4 $\mu\phi_o/\sqrt{Hz}$, including noise produced by the electric circuit and 2.1 $\mu\phi_o/\sqrt{Hz}$ in terms of the SQUID itself. These values are three times the theoretical values calculated by Tesche, et al. Further, these characteristics are 45 $ft/\sqrt{Hz}$ in terms of the magnetic field resolution at the pickup coil.


10μV

Fabrication of Variable-Thickness Bridge DC-SQUID Using Epitaxial YBaCuO Thin Films

906C7539E Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 97

[Article by N. Hashimoto and S. Kuriki, Hokkaido University, T. Terashima and Y. Bando, Kyoto University, K. Yamamoto, K. Hirata, K. Iijima, and K. Hayashi, Research Institute for Production Development]

[Text] It is known that when high-quality epitaxial YBCO thin films are placed in a superconducting state, there is a reduction of low-frequency noise. It is very difficult, however, to prepare Josephson devices by microscopically processing such epitaxial thin films. We prepared a DC-SQUID pattern and a variable-thickness bridge by sputter etching. This report outlines the results.

A YBCO thin film was prepared on a $SrTiO_3$ by the activation reactive vacuum evaporation process. The film thickness was 240 to 300 nm and the zero resistance temperature (Tc) was ~ 85K. To prepare a SQUID pattern, a stencil was prepared by electron beam lithography using a PMMA resist, a specimen was mounted on the RF sputtering unit cathode part, then etching was carried out at a gas pressure of 20 mTorr and an input power of 20W for 20 to 25 minutes. The bridge width was ~ 5 μm. Next, a slit of ~ 1 μm was provided for the bridge by PMMA and the film thickness was partially reduced by sputter etching the bridge for 10 to 15 minutes under the same conditions as in the preparation of the SQUID pattern. Later, to recover the Tc of the bridge and stabilize the device, heat treatment and oxygen plasma treatment were carried out in an oxygen atmosphere.

Figure 1 [not reproduced] shows a SEM image on DC-SQUID. The Tc declined only slightly after sputter etching the SQUID pattern and the bridge portion. Ic decreased according to the film thickness of the bridge. With respect to all the SQUIDs prepared, rounded I-V characteristics were observed in the vicinity of Ic. When microwaves were applied, shapiro steps were observed in some SQUIDs (Figure 2).

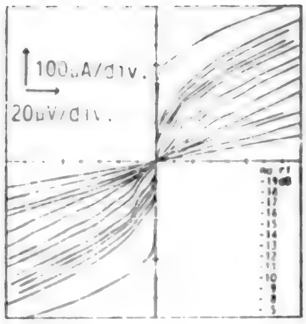


Figure 2. I-V Characteristics During Microwave Irradiation (30K)

Noise Characteristics of DC-SQUIDs Using YBCO Films Prepared by MO-CVD

906C7539F Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 97

[Article by H. Sasahara, A. Irie, M. Era, and T. Yamashita, Nagaoka University of Technology, H. Kurosawa, RIKEN Co., H. Yamane and T. Hirai, RIISOM, Tohoku University]

[Text] Using YBCO thin films formed on MgO substrates, we have so far prepared DC-SQUIDs with superior characteristics, by the MO-CVD process.[1] Holes of several μm or smaller in diameter were observed by SEM on MO-CVD films formed on MgO substrates, and microscopic grain boundaries[2] were observed by TEM. Noise may be reduced by preventing magnetic flux from being trapped by these holes and grain boundaries. We therefore formed an Au film on a DC-SQUID bank and attempted to improve the superconductivity of YBCO films using the proximity effect (ξ_N(4.2K)~750Å) between YBCO films and Au films. The output voltage, magnetic flux-noise conversion efficiency, noise voltage, and energy resolution of the DC-SQUID thus prepared are shown in Figure 1. The following characteristics, which are superior to the DC-SQUID (prepared using the same lot) on the bank of which Au films are not formed, were obtained at 4.2K. (The figures show the characteristics of a DC-SQUID, on the bank of which Au films are not formed.)

·Max. output voltage: about 120 μV (about 90 μV)
·Max. magnetic flux - noise conversion efficiency: about 1.1 mV/Φ_0 (about 0.5 mV/Φ_0)
·Min. magnetic flux noise: about 6 x $10^{-7}\Phi_0/\sqrt{Hz}$ (about $10^{-5}\Phi_0/\sqrt{Hz}$)
·Min. energy sensitivity: about 25 h (about 10 h)

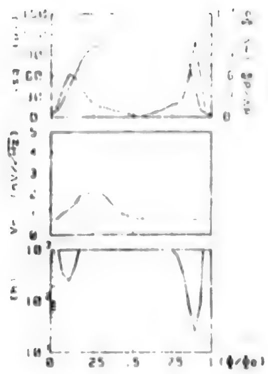


Figure 1. Characteristics of DC-SQUID

References

1. A. Irie, et al., Jpn. J. Appl. Phys., 28 (1989), L1816.

2. Suzuki, et al., preliminary report for the lecture meeting.

Magnetic Shielding Effect of Bi Oxide Superconducting Vessels

906C7539G Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 98

[Article by K. Hoshino, K. Katoh, S. Yamazaki, H. Takayama, and H. Takahara, MMS Co., Ltd. Corporate R&D Center, E. Sudo, TKR Division, H. Ohta and M. Aono, RIKEN]

[Text] Preface

We are carrying out research on the manufacture of superconducting shield vessels used to measure brain magnetic fields. We manufactured a large magnetic shield vessel, into which a SQUID fluxmeter can be inserted. Then, using an alternating magnetic field, we investigated shield effects at a weak magnetic field. As a result, it was found that Bi-based superconducting materials are stable and do not change with time compared with Y-based superconducting materials and that they are promising as magnetic shield materials.

Experiments and Results

Uniform Bi-Pb-Sr-Ca-Cu-O fine particles were prepared by the ethanol oxalate coprecipitation process and were calcinated to have a high Tc phase (110K phase) appear. Then the powder, in which a high Tc phase appeared, was formed by CIP into a cylindrical vessel with one end closed, and was burned. The size of the vessel was 150 mm in inside diameter, 320 mm in depth, and 10 mm in wall thickness (photo below). Shield effects were determined by converting (by means of an exciting coil) an alternating voltage into an alternating magnetic field and measuring a voltage induced into the detection coil installed inside the superconducting magnetic shield vessel using a lock-in amplifier. Thus, the ratio of an induction voltage V_{77K} at 77K to an induced voltage V_{RT} (i.e., V_{77K}/V_{RT}) was used as a shield effect. As a result, it was confirmed that the magnetic field (0.3 gauss) equivalent to the geomagnetism attenuated to 1/1,000,000 within a frequency range of 20 to 1,000 Hz in a Bi-based superconducting magnetic shielded vessel.

Application to Current Lead by YBCO Superconductors

906C7539H Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 98

[Article by S. Ozawa, J. Saitoh, M. Sano, N. Kohma, H. Yamamoto, M. Tanaka, M. Kaneko, Y. Matsubara, and T. Ogasawara, College of Science and Technology, Nihon University]

[Text] Cu wires are mainly used as current leads for superconducting magnets. Cu, however, is very high in thermal conductivity at low temperatures. The generation of heat by the lead itself cannot be disregarded for the superconducting magnets requiring a current of several hundred amperes. The use of oxide superconductors (whose thermal conductivity is lower than Cu) for current lead makes it possible to carry out heat insulation. Zero resistance also makes it possible to prevent the generation of heat by the lead itself. Thus oxide superconductors, with low thermal conductivity, allow the magnet to be operated in a more thermally efficient manner.

This time, we attempted to prepare Y-based crystals. We mixed Y_2O_3, $BaCO_3$, and CuO with each other at the specified rate. The mixture was calcinated and was crystallized by the QMG process.[1] Figure 1 shows the resistance rate-temperature characteristics of the specimen (obtained by crystallization) annealed in oxygen at low temperature. This specimen showed superconducting transition at 85K. Figure 2 shows an image of the composition of a similar specimen. This image shows that the specimen is polycrystals including impurity phases.

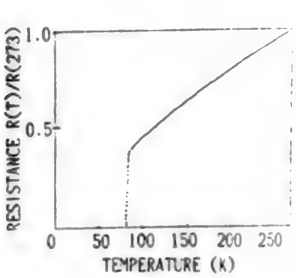


Figure 1. Resistance-Temperature Characteristics

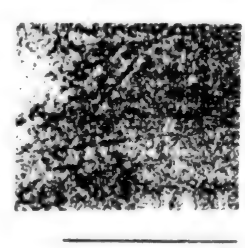


Figure 2. Image of Composition

We evaluated the relationship between the microscopic structure of these specimens and their basic superconducting characteristics and the operating characteristics of the current lead system used at 50~15K using a small refrigerator.

Reference

1. M. Murakami, et al., Jpn. J. Appl. Phys., 26 (1989) 1189.

Magnetic Bearings Using High-Tc Superconductor

906C7539I Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90
p 98

[Article by R. Takahata, Koyo Seiko Co., Ltd., T. Yotsuya, Ind. Tech. Res. Institute, Osaka Prefecture]

[Text] Preface

As one of the applied products of oxide high-Tc superconductors, magnetic bearings using the Meissner effect can be cited. We manufactured this bearing on a trial basis and conducted basic experiments while paying attention to its rotating performance. As a result, we found that the effect of magnetic flux having entered the superconductor is posing problems.[1,2] Such magnetic flux is thought not only to reduce the repulsion force but also to become a resistance interfering with the rotation of the magnet. Therefore, we devised equipment to measure such resistance.

Method of Experiment

Figure 1 shows the testing equipment. A permanent magnet was installed on the lower surface of the Koyo static pressure spindle received (in a non-contact manner) in the radial and thrust directions. Under the magnet, a superconductor cooled with liquid nitrogen was installed. After the spindle was rotated uniformly using gas turbine, the supply of gas turbine was stopped and the spindle rotation attenuation rate was measured.

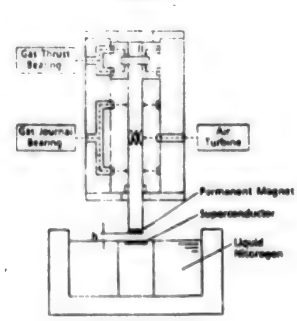


Figure 1. Evaluation Equipment for a Flux-Pinning Effect

Results

Time constants were calculated based on the spindle rotation attenuation rate and comparison was made in terms of the presence or absence of a superconductor. As a result, the rotation resistance of the penetrating magnetic flux was confirmed, but this resistance was found to be very small.

References

1. Takabatake, et al., Preliminary Report for 1989 Spring Applied Physics Society.

2. Takabatake, et al., Preliminary Report for 1989 Autumn Applied Physics Society.

Fabrication of Bulk Superconductor by the Mist Pyrolysis-Collision and Deposition Method

906C7539J Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 99

[Article by M. Awano and H. Takagi, Government Industrial Research Institute, Nagoya]

[Text] 1. Preface

Uniform ultra-microscopic superconducting particles directly synthesized by the mist pyrolysis process[1] are collided with and deposited on a substrate at high speed. This process[2] is used to prepare superconducting bulk materials, thick films, and wires at high speed by minimizing heat treatment, with an aim of putting oxide superconductors into practical application. This report outlines the results of study of this process.

2. Experiment

Using the mist pyrolysis process, we directly synthesized yttrium-based and bismuth-based (low Tc phase) superconducting particles (submicron order or smaller), transported them as aerosols, and collided them (in a vacuum chamber) with the substrate at high speed through a nozzle. Thus, we fabricated pressed superconducting powder, thick films, and linearly deposited films (Figure 1).

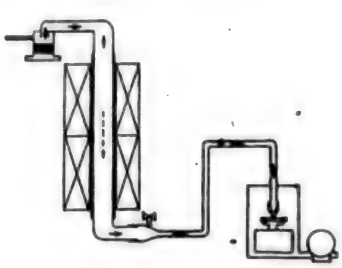


Figure 1

Figure 2

3. Results

Deposits (films) were formed on substrates maintained at room temperature for both yttrium-based and bismuth-based superconductors. These films showed superconducting phase X-ray diffraction patterns and also superconducting characteristics when the magnetization rate was measured. Crystal particles were fine bulk materials which came into close contact with the substrate (Figure 2). It was possible to control the shape and film thickness of deposits according to the ultra-microscopic particle formation conditions and substrate driving conditions. Crystal particles composing the bulk material were superconductors. However, since crystal particles were not fully bonded to each other (though microscopically), the bulk materials did not show superconducting characteristics as a transportation current where they were not post-heat-treated. We are currently trying to strengthen the bonding between crystal particles by further reducing the particle size of the formed superconductors and heating the substrates.

References

1. M. Awano, et al., Chem. Lett., 43 (1989), etc.

2. M. Awano, et al., Submitted to proceedings of ISS'89.

Preparation of Bi-Pb-Sr-Ca-Cu-O Superconducting Tapes by Laser Zone Melting Method

906C7539K Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 101

[Article by K. Tomomatsu, A. Kume, and H. Tominaga, Fujikura Ltd., T. Hara, K. Okaniwa, and T. Yamamoto, Tokyo Electric Power Co.]

[Text] We have already attempted to manufacture Bi-based high Jc superconductors by providing an orientation for crystals using the zone melting method and also by containing high Tc phases (110K phase). We developed a horizontal laser zone melting equipment and prepared a tape-shaped Bi-based superconductor. The results are outlined below.

Figure 1 shows an outline of the equipment. CO_2 laser is irradiated onto the superconductor powder applied on the base material tape and a melting zone is thereby formed. Then, by moving the tape, superconductor tape is prepared continuously. It is known that low Tc phases (80K phase) are formed from the melting state in the case of the Bi system. The low Tc phases formed, however, are not a congruent composition. Therefore, to obtain an entirely uniform structure, it is necessary to narrow the width of the melting zone. Our developed equipment condenses CO_2 laser beams in a line and can form a narrow melting zone over the entire tape width. In addition, irradiating similar laser beams to the tape from both the upper and the lower side of the tape makes it possible to control not only the temperature gradient in the thickness direction of the tape but also the crystal orientation in the longitudinal direction of the tape.

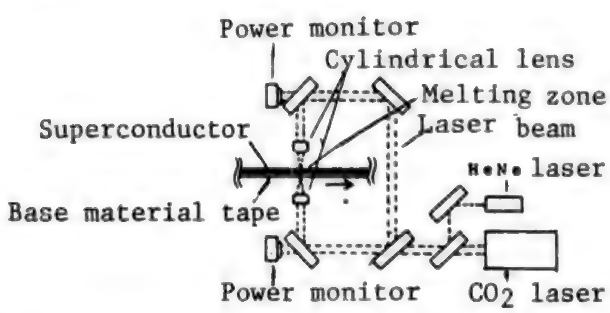


Figure 1. Schematic Drawing of Horizontal Laser Zone Melting Method

We used tape prepared by applying powder with a composition $Bi_{1.75}Pb_{2.37}Sr_2Ca_2Cu_3O_7$ to various types of metals and formed melting zones ranging from 5 mm/h to 50 mm/h. The specimens thus obtained showed a crystal orientation. X-ray analyses have revealed that a low Tc phase has been formed on the 5 mm/h specimen. Further, a Tc of 94K was obtained by heating the 50 mm/h specimen.

Preparation and Characterization of Tl-Bi-Ca-Sr-Cu-O Superconducting System

906C7539L Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90
p 102

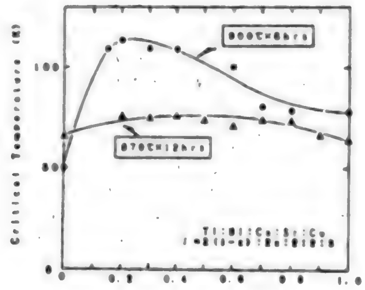
[Article by Y. Torii, H. Takei, and K. Tada, Sumitomo Electric Ind. Ltd.]

[Text] 1. Preface

At the lecture meeting held in spring 1989, we reported that a superconducting phase (a = 3.8Å, c = 12.0Å tetragonal) is formed in the Tl-Bi-Ca-Sr-Cu-O system at a critical temperature of about 70K. We studied combination compositions and synthesizing conditions and obtained a superconducting phase with Tci = 115K. The method of preparing such superconducting phase and results of evaluation of its characteristics are reported below. We also investigated the effects of additive elements (Pb, In, Sn, Sb) on the formation of superconductors. These results are also reported.

2. Results

When the combination composition was Tl:Bi:Ca:Sr:Cu = 2(1-x):2x:2:2:3($0 \leq x \leq 1$), two phases whose critical temperatures are different were formed. When the amount of addition of Bi was x = 0.2 and the sintering temperature was 900°C, one phase showed a maximum Tc of 115K. X-ray diffraction showed that this phase was a tetragonal phase and its lattice constant was a = 3.82Å and c = 15.29Å, re pectively. Further, EDX analyses identified the composition of this phase as $(Tl_{0.7}Bi_{0.3})Ca_2Sr_2Cu_3O_x$. It has also been revealed that an additive element such as Pb is substituted in the superconducting phase and forms a (Tl, Bi, Pb)$Ca_2Sr_2Cu_3O_x$ phase.



Preparation and Property of Superconducting Oxide/Ag Clad Sheats by Melt-Quenching Method

906C7539M Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 103

[Article by A. Otomo, K. Eto, and A. Fukizawa, Central Research Laboratory, Showa Denko K.K.]

[Text] Preface

It is known that if Bi-based oxide superconductors are melted and quenched, they easily turn into an amorphous state. The melting/quenching process is worthy of note as a process to achieve high Jc. Amorphous specimens, however, are fragile and involve difficulties in being lengthened. In addition, no orientation can be found in the particles of specimens that have undergone heat treatment. No high Jc has ever been reported in cases where the melting/quenching process was used.

We added Ag to the melted material to prepare a Bi-based 90K phase/Ag clad foil and thus prepared a highly tough and oriented specimen. Then we investigated the superconducting characteristics of the specimen and also the heat treatment conditions, film thickness dependence, etc., of the microscopic structure.

Experiment

The mixed powder with a composition Bi:Sr:Ca:Cu = 2:1.8:1.2:3) was preliminarily burned, mixed with Ag powder at an equal weight ratio, and melted using an infrared lamp heater. The melt was placed and quickly cooled between the double copper rollers (gap: 20 μm) which rotate at a high speed of 3,000 rpm. A clad foil consisting of two layers, an amorphous layer with the stated composition and an Ag layer, was produced. This clad foil was heated at 760° to 860°C and a superconductor was thus prepared. Figures 1 and 2 show the X-ray diffraction patterns of the specimen melted/quenched (Figure 1) and heat treated (Figure 2), respectively. No crystal phases were observed in the specimen after the melt/quenching method was applied, but a typical amorphous pattern was observed. Partial melting can be seen in the Figure 2 specimen. It is also observed that a 90K phase is c-axis oriented in the thickness direction. Such orientation can be seen in specimens heat

treated at lower temperatures, but is much more evident in the vicinity of the melting point. Thinner specimens showed a tendency to be oriented. Other characteristics will be reported in detail at the meeting.

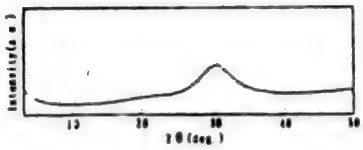


Figure 1

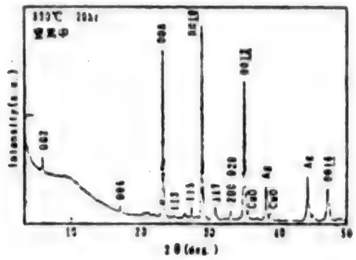


Figure 2

Growth of YBCO Crystals With Verneuil Method by Laser-Heating

906C7539N Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90
p 103

[Article by I. Nakada, K. Ishida, S. Fujimoto, K. Yuminaga, T. Kurosu, M. Iida, and M. Itoh, Tokai University, I. Ogura, K. Koga, and S. Sato, Tokyo University]

[Text] As yet there is no system established for preparing oxide high-temperature superconducting YBCO single crystal. This is partly because crucibles that do not react with crystal raw materials cannot be found. If a mixture of Y_2O_3, $BaCO_3$, and CuO is used to prepare YBCO, a melt with a composition $Ba_xCu_yO_z$ is formed. Then, Y_2O_3 reacts with the melt and YBCO single crystals are produced. We have already learned that this melt shows a strong chemical reactivity at high temperatures and that all the crucibles so far used are corroded. Therefore, we used the Verneuil method (using laser beams as a heat source) as a non-crucible cultivation method. As the phase diagram shows, however, it is not possible to melt and grow crystals by direct melting. YBCO crystals, therefore, were prepared by the melting process, in which the composition was disconnected from YBCO. The pool thus prepared was heated by the general electric furnace, excess flux was melted away, and a YBCO crystal lump was taken out. YBCO crystals grew to a size of about 1 mm. However, when taken out from the crystal lump, the YBCO crystals cleaved and were subdivided and, therefore, the crystal size became about 0.5 mm.

The superconducting transition temperature of crystals annealed at 600°C was 91K. Domain patterns were observed by using a differential interference microscope. Using a four-axial diffractometer, we investigated the relationship between crystal directions and domain contrast under the differential interference microscope, and with results as shown in Figure 1.

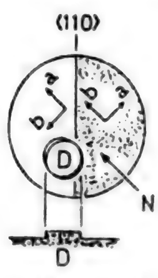


Figure 1

Properties of Oxide Superconducting Films on a New Substrate: $YAlO_3$ Single Crystal

906C75390 Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 113

[Article by H. Asano, S. Kubo, and O. Michikami, NTT Laboratories, T. Tokairin and K. Shiroki, TOKIN Corp.]

[Text] Preface

To apply oxide superconducting thin films to devices and high frequency, it is an urgent task to develop single crystal substrates (that can be put into practical use) for epitaxial growth. As a new substrate material, we adopted $YAlO_3$, which makes it possible to obtain single crystals with a good quality, and prepared thin films using $YAlO_3$ substrates. Then, we studied the applicability of $YAlO_3$ as a substrate material for oxide superconductors. The results are outlined below.

Experiments and Results

Table 1 presents the basic properties of $YAlO_3$. The crystal structure is orthorhombic perovskite and the dielectric constant is about 6. $YAlO_3$ single crystals were grown by the pickup method (direction: (001)). The crystals were sliced and ground to prepare a substrate. The X-ray topography on the substrate shows that a good crystal quality is maintained over the entire substrate surface. On this substrate, a 123 structure compound ($Ln_1Ba_2Cu_3O_x$: Ln = Y, Eu) thin film was formed to a thickness of about 3,000Å at a substrate temperature of 600°C by dc magnetron sputtering or by co-vacuum evaporation. X-ray diffraction showed that a c-axial epitaxial thin film with a good crystallizing performance had grown. Figure 1 shows a typical electric resistance-temperature curve on this thin film. An almost ideal value, that is, Tc_{zero} = 91K, was obtained. SEM observation showed that the film surface properties are smooth. From these results, it can be judged that $YAlO_3$ single crystals have considerable potential as a substrate material for oxide superconductors.

Table 1. Basic Properties of $YAlO_3$

Formula	$YAlO_3$
Structure	Orthorhombic Perovskite
Lattice constants	a_0 = 5.179 A b_0 = 5.329 A c_0 = 7.370 A
Melting point	1875°C
Thermal expansivity	2.2 x 10^{-6}/°C
Dielectric constant	~6

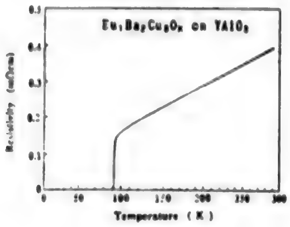


Figure 1. Electric Resistance-Temperature Curve on Thin Film

X-Ray Irradiation for Cuprate Superconducting Thin Films

906C7539P Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 119

[Article by S. Kohiki, K. Setsune, and K. Wasa, Matsushita Electric, S. Fukushima and Y. Gohshi, University of Tokyo]

[Text] To put copper oxide superconductors into practical use, it is indispensable to study magnetic flux pinning. In particular, it is important to make magnetic flux creep activation energy larger by creating and controlling stable lattice defects, thereby obtaining a large current density at high temperatures. It has already been proved effective to use X-rays to introduce lattice defects into superconducting thin films with a large current density. Here, we report on the increase of critical current density that arises from annealing in the presence of oxygen and X-ray irradiation of superconducting thin films.

X-rays were applied to a $GdBa_2Cu_3O_x$ thin film prepared by sputtering and then the film was annealed in oxygen. As a result, the critical current density of the film grew as shown in Figure 1. The film showed little magnetic relaxation at about 50K or lower. The magnetic relaxation grew at about 70K, which, however, is much smaller than that of thin films, to which X-rays were not applied. If the magnetic flux creep activation energy is calculated, the results are: where X-rays were applied: 0.25 eV; where X-rays were not applied: 0.1 eV. Thus, X-ray application caused the magnetic flux creep activation energy to increase 2.5 times. The current density obtained based on magnetization agreed with the transportation current density; SEM observation showed that grain boundaries decreased; X-ray diffraction showed that the orientation was improved and that there are no foreign phases. It is thought, therefore, that grain boundaries and non-superconducting precipitates cannot become pinning centers. Further, it has already been reported that twins cannot become pinning centers. When X-rays were applied to a $RBa_2Cu_3O_x$ system thin film, its activation energy grew 2.5 times and the critical current density increased substantially. This is because stable pinning centers were introduced into crystals by X-ray irradiation and the subsequent annealing in oxygen. It is thought that oxygen deficiencies in the lattice operate as pinning centers.

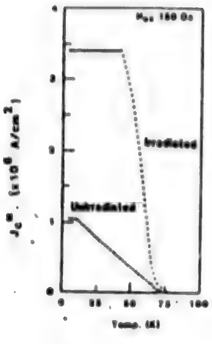


Figure 1

Effect of Silver on Superconducting Y-Ba-Cu-O

906C7539Q Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 119

[Article by Takashi Ohyama, Kobe University, Mineo Itoh and Hiroyuki Ishigaki, Kinki University]

[Text] We have already reported[1] on the effect of Ag(0-7 wt%) on the critical temperature Tc, hardness Hv, and density D of superconducting Y-Ba-Cu-O. Now we report on the relationship between the critical current density Jc of the specimen and the compression pressure P when the specimen was prepared, and between Jc and Ag mixing rate C (0 to 30 wt%).

We mixed Ag powder (particle size: 20 μm) of 0 to 30 wt% with calcinated Y-Ba-Cu-O powder and prepared pellets by changing pressures P from 0.05 to 1.0 GPa. Figure 1 shows the relationship between the pressure P and Jc (A/cm^2, at 90K) where the Ag mixing rate C was parameterized (0, 3, 7 wt%), and also between the pressure P and the critical temperature Tc^{zero} (temperature at which electric resistance amounts completely to zero) where the Ag mixing rate C was 3 percent. Figure 2 shows the relationship between the mixing rate C (0 to 30 wt%), the pellet critical temperatures Tc^{zero}, Tc^{onset} (temperature at which superconducting transition begins), and Jc (85K, 90K) where P = 0.1 GPa. Highly pure air (99.999 percent) was used to prepare all specimens. From these, we have learned the following: 1) Mixture of Ag with superconducting materials in an appropriate quantity (Cs, 3 to 7 wt%) makes it possible to greatly improve Jc values. 2) Tc^{zero} rises several K's with respect to Cs. 3) Tc^{onset} remains almost constant with respect to C.

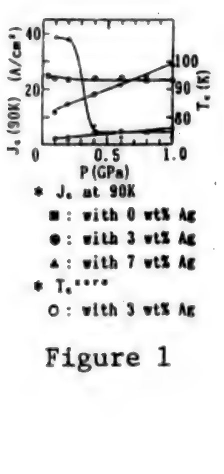


Figure 1

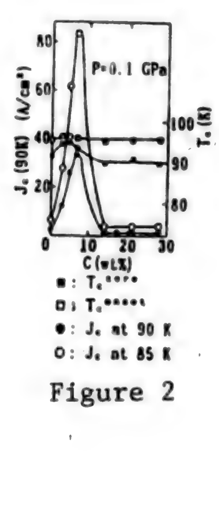


Figure 2

Reference

1. Ohyama, et al., 36th Applied Physics-Related Association Preliminary Report, 2a-PC-11, p 111 (spring 1989).

History Effects and Microstructure of BiPbSrCaCuO Ag-Sheathed Wires

906C7539R Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 120

[Article by T. Hikata, H. Mukai, M. Ueyama, K. Sato, and H. Hitotsuyanagi, Sumitomo Electric Ind., Ltd.]

[Text] 1. Preface

We have already learned that high-temperature single phases, highly oriented crystal particles, improvement of crystal grain boundaries, microscopic dispersion of non-superconducting phases, etc. facilitate the increase in Jc of BiPbSrCaCuO high-temperature superconducting Ag-sheathed wires.[1,2] This report outlines Jc-B characteristics and the accompanying history effects.

2. Experiments and Results

Oxide or carbonate powder was blended, sintered, and pulverized. Then, the pulverized powder was put in an Ag pipe, processed into the form of tape by drawing, rolling, pressing, etc., and heat-treated. Figure 1 shows Jc-B characteristics (up to 0.2T) of wires whose Jc ranges from 1,650 to 25,000 A/cm^2 (at zero magnetic field) at 77.3K. As Jc is improved in zero magnetic field, Jc in a magnetic field tends to decline slowly. Figure 1 also shows that history effects involved with the fluctuations of the magnetic field become smaller. History effects were insignificant when the specimen with Jc = 25,000 A/cm^2 was used. This shows that weak links have been improved at grain boundaries. Meanwhile, history effects were again observed in regard to Jc-B characteristics at 4.2K. At the meeting, we will also report the results of observations by TEM and SEM.

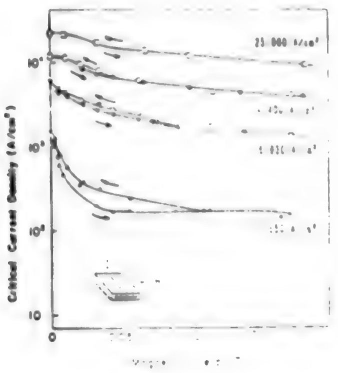


Figure 1. Jc-B Characteristics of Wires

References

1. T. Hikata, et al., JJAP 28 (1989) L1204.

2. K. Sato, et al., Proc. of ISS'89 in Tsukuba.

AC Loss of Bi-Pb-Sr-Ca-Cu-O Ag-Sheathed Wires

906C7539S Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90
p 120

[Article by Y. Ando, S. Akita, and T. Tanaka, CRIEPI, T. Hikata, K. Sato, and H. Hitotsuyanagi, Sumitomo Electric Industries]

[Text] In order to apply high Tc superconductors to electricity, it is important to grasp the ac loss characteristics. Therefore, of the ac loss characteristics, the most basic hysteresis loss was evaluated in regard to Bi-Pb-Sr-Ca-Cu-O Ag-sheathed wires. Figure 1 shows the maximum magnetic field dependence of hysteresis loss at 79K when a magnetic field was applied in parallel with and vertically to the tape surface. These measurements were carried out for two-core wires shown in Figure 2. As shown in Figure 2, the aspect ratio at the superconducting part is more than 30. If the simple system was followed, the ratio of ac loss must be equal to the aspect ratio of 30 or more. As shown in Figure 1, however, the ac loss even where a magnetic field is applied vertically to the tape surface amounts to only three times that of a magnetic field is applied in parallel with the tape surface. This suggests that superconducting tape wires may be able to be used even where a magnetic field is applied vertically to the tape surface, from the ac loss standpoint. We will report detailed results at the meeting. Further, to investigate the effect of use of multicore wires, we prepared two types of wires--single-core and two-core wires whose superconducting part is similar in sectional shape (Figure 2) and compared these two types of wires. At 77K and 0T, the single-core wire showed a Jc of 9450 A/cm^2 and the two-core wire showed 7090 A/cm^2. The results of the comparison, including detailed data, will be reported at the meeting.

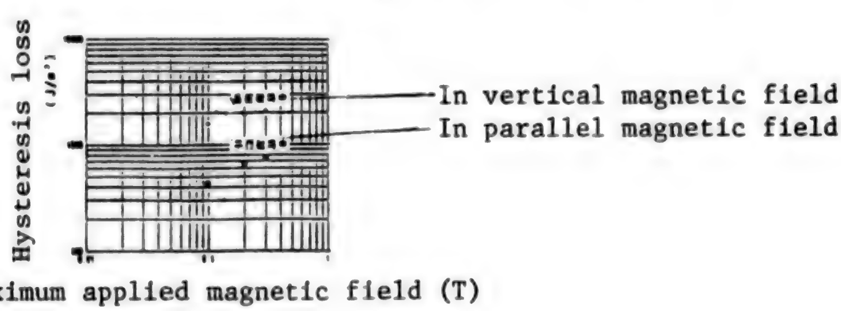


Figure 1. Hysteresis Loss at 79K

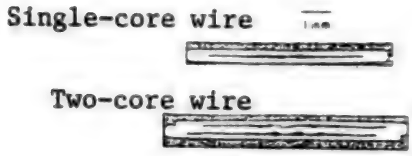


Figure 2

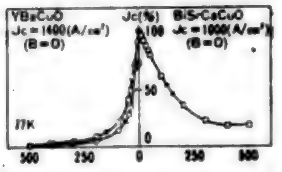
Characteristics of Flux Trap on $Bi_2Sr_2CaCu_2O_y$ and $YBa_2Cu_3O_y$ Ag-Clad Wires

906C7539T Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 121

[Article by T. Hara and T. Yamamoto, Engineering Research Center, Tokyo Electric Power Co., H. Hoshino, Kandenko]

[Text] Magnetic characteristics are measured not only for bulk materials and thin films but also for Ag-clad wires. The relationship with flux trap and pinning are also discussed. Reports of such discussions have recently increased.[1] We measured the magnetic field (B) dependence of critical current density (Jc), hysteresis characteristics, and flux creep characteristics of several samples (taken from the same lot) from bismuth Ag-sheathed wires (into which the melting process was introduced) and yttrium Ag-sheathed wires (prepared by the sintering process), and studied the flux trap characteristics of these wires.

Figure 1 shows the Jc-B characteristics of these wires. Yttrium-based wires show a larger hysteresis that arises from the up and down of magnetic field. This suggests that yttrium-based wires trap magnetic flux, at weak bonding points such as grain boundaries, more strongly than bismuth-based wires. Figure 2 shows magnetic flux creep characteristics. From this figure, it is evident that yttrium-based wires are superior in flux trapping to bismuth-based wires. Meanwhile, Figure 1 shows that the Jc characteristics of bismuth wires are satisfactory with respect to magnetic field. This can be estimated to have resulted from a decrease in weak bonding because of use of the melting process. Whether such a flux trap can result in pinning points is an important research subject, with the aim of determining how much Jc rises.



Applied magnetic field (Oe)

Figure 1. Jc-B Characteristics of Y- and Bi-Based Ag-Sheathed Wires

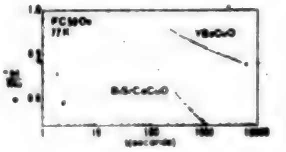


Figure 2. Magnetic Flux Creep Characteristics of Y- and B-Based Ag-Sheathed Wires

At the meeting, we will study and report on the relationship between flux trap and pinning, including the properties of powder.

Reference

1. K. Heine, et al., Appl. Phys. Lett., 55 (23), p 2441 (1989).

AC Characteristics of Silver-Sheathed Tl-Ba-Ca-Cu-O Superconducting Tape-Shaped Wires

906C7539U Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 121

[Article by T. Sasaoka, M. Kanaoka, Y. Sekii, M. Seido, and P. Hosono, Hitachi Cable Ltd.]

[Text] Preface

There are many reports on the characteristics of oxide superconductors during the electrification of a dc current. Many indefinite points, however, have been reported with respect to ac characteristics such as ac loss and ac critical current. We measured the ac characteristics of Ag-sheathed tape-shaped superconducting wires (being currently developed), by the four-terminal method. The outline is reported below.

Method of Measurement

For the ac measurement of the superconductor, a large current (~35A) was introduced directly into the specimen and a microvoltage was measured using a lock-in amplifier. The induction voltage was reduced to 1 μV or smaller (confirmed in terms of the standard resistance of an ac resistance, 1 μΩ) by compensating for the reactive component of inter-terminal voltage using a variable mutual induction coil.[1]

Results of Measurement

Figure 1 shows the V-I characteristics of a Tl-based Ag-sheathed tape wire (thickness: 0.3 mm) where measured frequencies were parameterized. Voltages V on the axis of ordinates are the values after the reactive component was compensated for, and are equivalent to losses occurring between electrodes. With respect to V-I characteristics during the flow of an ac current, a microscopic ac resistance was observed even in the region below the critical current Ic during the flow of a dc current. If the V-I characteristics are indicated as $V \propto I^n$, n = 2~3. n values decline with frequency. In the region that exceeds Ic, the wire showed values almost equivalent to n values during the electrification of a dc current. The same tendency can be observed in the specimens with a different Ic. This is thought to show the ac loss of oxide superconductors.

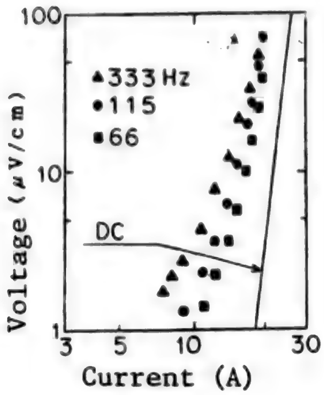


Figure 1. AC Electrification Characteristics of Ag-Sheathed Superconducting Wire

Reference

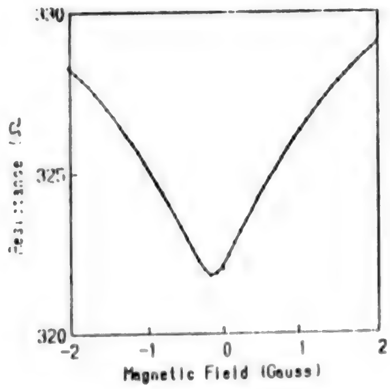
1. Sugiyama, Tsutsui, Sanbonsugi, All Japan Electricity Meeting, 1981, No. 1210.

Magneto-Sensor Using BSCCO Thin Film

906C7539V Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 127

[Article by Tsutomu Yotsuya, Osaka Pref. Ind. Rech. Res. Institute, Hirofumi Imokawa, Tatsuta Electric Wiring, Masahiro Yoshikawa, Hosokawa Micron, Shuji Miyake, Daihen]

[Text] It is well known that the presence of crystal grain boundaries causes the electric resistance of oxide superconductors to be more dependent on the magnetic field in the region which is in the critical or lower temperatures. Small critical current density is not desirable in view of practical application of superconductors. Several characteristics, however, have already been reported on the use of YBCO bulk materials as magnetic sensors using the said characteristics of oxide superconductors. The author et al. measured the characteristics of oxide superconductors as magnetic sensors using BSCCO, which is said to be more sensitive to magnetic field than Y-based superconductors. We deposited a Bi(Pb)SrCaCuO thin film on an MgO(100) single-crystal substrate by rf sputtering and heat-treated it. The result was a thin film consisting of a mixture of two phases, high-temperature and low-temperature, and cut it into thin wires by YAG laser. Tc_{on} and Tc_{o} of the specimen thus prepared were 110K and 60K, respectively. Electric resistance was little dependent on temperatures at 77K (plateau region). The characteristics of the specimen as a magnetic sensor were measured at 77K. As a result, a sensitivity of 4.25 mV/Gauss (dR/dB = 4.25 Ω/Gauss I = 1 mA) was obtained. The measured critical magnetic field (estimated based on Johnson noise) in this case was 10^{-5} Gauss. We will report on the details at the meeting.



Development of Displacement Sensor Using Y-Ba-Cu-O Superconductor

906C7539W Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90
p 127

[Article by Takashi Ohyama and Masahiro Ishidoh, Kobe University, Mineo Itoh, Kinki University]

[Text] In our work on sensors using Y-based superconductors, we are currently carrying out research on displacement sensors (used at low temperatures) which are superior in linearity, sensitivity, and stability.[1] This report outlines our basic research on this sensor.

Figure 1 shows a structure of a superconducting displacement sensor. The inductance of the coil (inner diameter 12 mm, outer diameter 14 mm, length 27 mm, and number of winds, 1,200 turns) shown in the same figure, is 6.7 mH. The core part is a Y-based superconducting rod (diameter 9 mm and length 23 mm). Where a magnetic substance is used for the core, provided such core is inserted into the coil, the inductance of the coil increases. The superconducting rod, however, is a completely antimagnetic substance and if the superconducting core is inserted into the coil, the inductance of the coil decreases. Therefore, if changes in inductance are detected as changes in voltage or impedance, the superconducting core can be used as a displacement sensor. Figure 2 shows voltage change-displacement characteristics where the frequency (f) of the excitation power supply is parameterized. We also used a cylindrical (outer diameter 9 mm, inner diameter 5 mm, and length 23 mm) superconducting core and were able to obtain the same characteristics as those shown in Figure 2. From these, we have learned the following regarding the displacement sensor using a Y-Ba-Cu-O superconductor: 1) good linearity; 2) stable to the passage of time; 3) heat cycle (77.4K $\leftrightarrow$ 300K) was applied more than 20 times but no changes occurred in the characteristics shown in Figure 2; 4) displacement would be measured with high sensitivity.

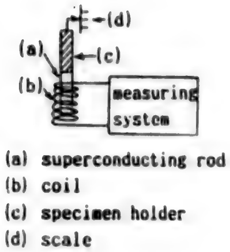


Figure 1

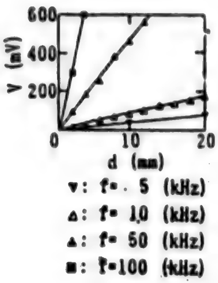


Figure 2

Reference

1. T. Ohyama, et al., Proc. 11th Inter. Conf. Magneto Technol., in press, 1989.

Optical Response of Bi-Sr-Ca-Cu-O Thin Films

906C7539X Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90
p 128

[Article by S. Ohya, K. Kobayashi, Y. Hirabayashi, Y. Kurihara, and
S. Karasawa, Industrial Research Institute of Kanagawa Prefecture]

[Text] Preface

We have already prepared a Bi-Sr-Ca-Cu-O thin film with a high superconductor transition temperature on an $LaAlO_3$ (1012) substrate using the excimer laser method[1] and studied its response to the irradiation of light. Light was applied to the film and the film showed a maximum amount of voltage shift in the superconducting transition region with respect to both bias and temperature dependency. We studied the light response characteristics of a superconducting thin film when the frequency of light chopper was changed.

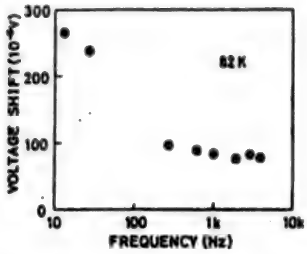
Experiment

A thin film was prepared by the method previously reported.[2] The characteristics were measured by the dc four-terminal method. A He-Ne (633 nm) laser of 15 mW was used as a light source and the amount of voltage shift was measured using a lock-in amplifier by changing the frequency of light chopper.

Results

Tc,zero = 94K. The amount of voltage shift of the thin film in high Tc phases (82K) was measured by illuminating light at different light chopping frequencies. The results are as shown in the figure below. The amount of voltage shift became larger when the chopping frequencies were low frequencies (~13 Hz). When the chopping frequency exceeded 1 kHz, the amount of voltage shift became almost constant. Even at each chopping frequency, the current bias dependence of amount of voltage shift was present.

Acknowledgment: The $LaAlO_3$ substrate was offered by Shinko Co., Ltd.



Chopping Frequency/Amount of Voltage Shift

References

1. 50th Applied Physics Society Lecture Meeting preliminary report series 29p-Q-2.

2. S. Ohya, et al., Jpn. J. Appl. Phys., 28 (1989) L978.

Photo Response of Y-Ba-Cu-O Thick Film

906C7539Y Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 128

[Article by Tadashi Kozawa and Takumi Minemoto, Kobe University, Mineo Itoh, Kinki University]

[Text] We have already reported that when light is applied to Y-based superconducting thick films, changes in the electric characteristics of films appear.[1] We investigated the time response of thick films to light and their sensitivity characteristics. This report outlines the results.

Two non-superconducting buffer layers of the same quality as that of high Tc superconductors, were provided on an alumina substrate and a superconducting thick film (thickness: about 100 μm and width: about 3 mm) was formed on the buffer layers.[2] Figure 1 (a) shows the changes in the output voltage of the thick film with respect to time when the irradiated light (light strength: about 0.2 W/mm^2) was chopped with a constant current of 3 mA applied to the film. Figure 1 (b) shows the strength waveform of irradiated light. As shown in the figure, the time response of this film is not so satisfactory, which indicates that changes in output voltage during the irradiation of light were caused by light operating as heat on the thick film. Figure 2 shows the sensitivity of the film to the applied current. No large changes occurred in the resistance-temperature characteristics, even though heat cycles (room temperature ↔ 77.4K) were applied about 100 times. We intend to proceed with systematic research on spectrum characteristics based on single wavelength, thick films to improve light response characteristics, and the shape of thick films.

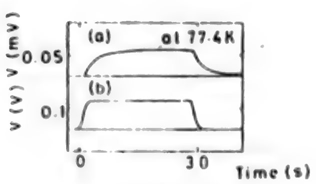


Figure 1

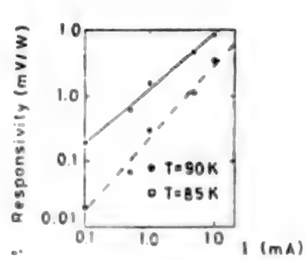


Figure 2

References

1. Ozawa, et al., 50th Applied Physics Society Lecture Meeting, 29P-Q-3, p 153 (spring 1989).

2. M. Itoh, et al., Jpn. J. Appl. Phys., Vol 26 (1988) L420.

Optical Detection in High-Tc Superconducting Thin Films

906C7539Z Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 128

[Article by K. Tanabe, Y. Enomoto, S. Kubo, and H. Asano, NTT Optoelectronics Laboratories]

[Text] Preface

We are studying applicability of high Tc superconductors as infrared light detecting devices. We have already reported that when comparatively low Tc and Jc LSCO (100) and YBCO (110) thin films are exposed to laser beams of 1.3 μm in wavelength, they show a sensitivity of about 20-30 V/W at low temperatures because of the nonbolometric structure. We investigated response characteristics in detail at about 77K, using a YBCO thin film with a higher Tc. The results are described below.

Experiments and Results

We prepared a weak bonding structure of 13 x 13 μm by ion milling with respect to (103), (001) epitaxial thin films (thickness: about 100 nm) deposited by reactive vacuum evaporation and dc magnetron sputtering and a granular thin film deposited on a sapphire substrate. Then, we investigated the effect of infrared rays on these films. Figure 1 shows the temperature dependence of detected voltage and dc voltage when a bias current was directed internally through the plane of Cu-O (103) thin film. The detected voltage showed its peak in the vicinity of Tc when a bias current of 2 mA was applied. The response appears to be bolometric. The detected voltage standardized at dV/dT showed a tendency to increase at temperatures lower than Tc as the temperature declines and the bias current increases as shown in Figure 2. Thus, it can be demonstrated that a response based on the non-bolometric structure is apparently present on epitaxially grown thin films with a high Tc and Jc.

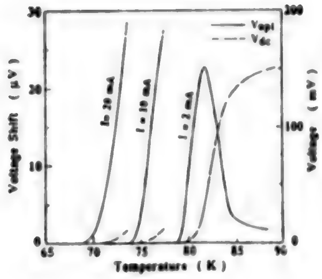


Figure 1. Temperature Dependence of Detected and dc Voltage (P = 20 μW)

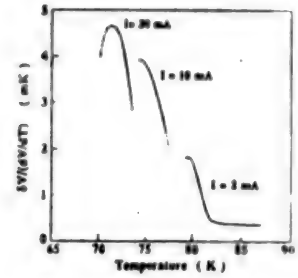


Figure 2. Temperature Dependence of Standardized Detected Voltage (f = 110 kHz)

Infrared Detector Using High-Temperature Superconductive BaYCuO/Ag_2O Metal Composite Thick-Film

906C7539aa Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 129

[Article by N. Oda, M. Yasui, T. Yamamoto, and H. Sato, Dept. of Elect. Engr., National Defense Academy]

[Text] We proposed light detectors using high Tc superconducting BaYCuO/Ag_2O metal compound thick films and reported the effect of electrode shape, film thickness, and external magnetic field on voltage sensitivity response V_R and time response.[1,2] We modified the shape of the detecting part thick film material to improve both V_R and τ, and completely immersed the detecting part in liquid nitrogen. Then, we applied light to the detecting part immersed in nitrogen, using optical fibers. Thus, we attempted to stabilize outputs and reduce noise. This report outlines the results.

Figure 1 shows a schematic flow diagram of the experiments. The equipment is the same as in the previous experiments, except for the modifications noted above. Figure 2 shows the strength characteristics of incident light with respect to detected voltage as bias current being parameters. The detected voltage changed almost linearly to an incident light strength of about 1 W. V_R and τ were improved about two times and by one-half, respectively. We will report on the frequency response at the meeting.

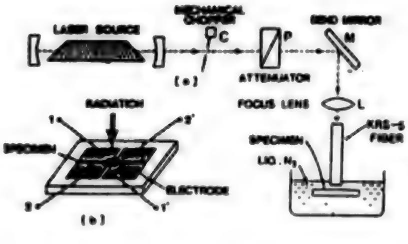


Figure 1. Schematic Flow Diagram of Experiments

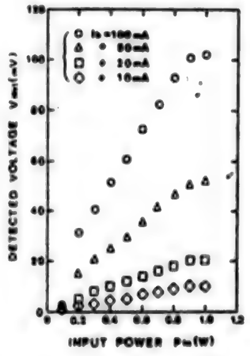


Figure 2. Characteristics of P_{in} to V_R

References

1. Yasui, Yamamoto, Sato, Applied Physics Society Spring Meeting 1989 4a-B-8.

2. Yasui, Yamamoto, Sato, Applied Physics Society Autumn Meeting 1989 29p-Q-1/I.

Evaluation of High-Tc Superconducting Strip Line

906C7539bb Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90
p 130

[Article by Y. H. Ohashi, M. Niwa, K. Kawabata, and M. Fukuchi, Keio University, K. Ohashi, Tamagawa University]

[Text] The use of superconducting materials has proved to be effective for high-speed signal propagation lines and microwave cavities. In particular, oxide superconductors with a large energy gap have a low density of normal electrons and can meet the required purposes. Strip lines are formed by modifying parallel, plate waveguides and are provided with a grounding conductor and a strip conductor. They propagate electromagnetic waves by applying an electric field between these two conductors. These lines are of a plane structure and are suitable to prepare small, light, and economical circuits. They are superior in compatibility with semiconductor parts and are receiving much attention.

A yttrium-based superconductor and an alumina substrate (2.5 x 2.5 x 0.1 cm) were used. A thick film of 1 mm in line width was formed on the substrate. When the line sintered on the substrate turns into superconducting state, the resistance greatly decreases and the line becomes a resonator. As a result, multiple reflections must be observed at both ends of the line. Therefore, we measured reflected waves based on S_{11} response by the time domain method (frequency range of microwaves used: 1G-20G Hz) using the HP8510A network.

Figure 1 shows a strip line which is placed in a non-superconducting state. The peak at 3.5 ns shows a reflection at the connection between the coaxial line and the strip line. The peak at 4.1 ns shows a reflection at the end of the strip line which remains opened. It can be demonstrated that reflected waves rapidly attenuate under the non-superconducting state.

Figure 2 shows a strip line placed in a superconducting state. The attenuation of microwaves decreased, the line became a resonator, and microwaves reflected at both ends of the strip line. The repetition line agrees with the time required for microwaves to go and return on the strip line.

Figure 1

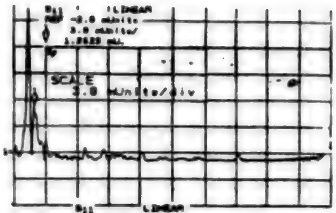
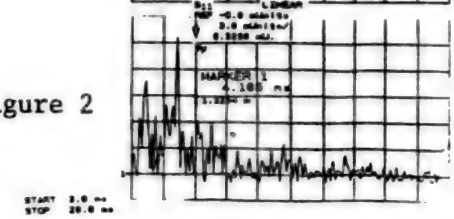


Figure 2



Superconducting Tℓ-2223 Thick-Films Prepared by the Plasma Spraying

906C7539cc Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 135

[Article by Y. Yoshida, T. Matsumoto, Y. Kojima, K. Aihara, T. Kamo, and S. Matsuda, Hitachi Res. Lab., Hitachi Ltd.]

[Text] Preface

We formed a Tℓ-based superconducting thick film using the plasma thermal spraying method and studied its superconducting characteristics and structure.

Method of Experiment

We thermally sprayed YSZ (stabilized zirconia) on a hastelloy x substrate and formed a diffusion barrier layer. Then, we prepared a film of 100 μm in thickness on this diffusion barrier layer by plasma thermal spraying, using two types of powder, $(Ba_{1.6}Sr_{0.4})Ca_{2.0}Cu_{3.0}O_x$ and $(Ba_{1.6}Sr_{0.4})Ca_{2.0}Cu_{3.0}O_x$ + 5 wt% Ag_2O (to which Ag was added). This film was heated in a Tℓ vapor phase. Thus, we prepared a Tℓ-based superconducting thick film. We conducted heat treatment at temperatures ranging from 840° to 870°C and in time periods ranging from 30 minutes to 20 hours.

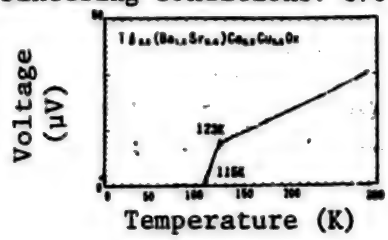
Results

Where Ag was not added, the superconducting characteristics of the film heated at 870°C for three hours were Tc = 115K (Figure 1) and Jc = 400 A/cm^2 (77K). The results of crystal structure analyses showed that the film consists of a mixed phase of a 2223 phase and a 2212 phase. Meanwhile, where Ag was added, Tc = 105K and Jc = 2500 A/cm^2 (77K) were obtained by heating the film at 840°C for 10 hours. The major crystal phase of the film was a 2223 phase and a slight impurity phase was observed.

This research was carried out as a research theme in the Superconducting Power Generation-Related Equipment and Material Technology Research Association under a contract awarded by the New Energy and Industrial Technology Comprehensive Development Organization, as a part of the moonlight program "Superconducting Power Applied Technological Development" established by

the Agency of Industrial Science and Technology, the Ministry of International Trade and Industry.

Sintering conditions: 870°C, 3h



Temperature Dependence of Electric Resistance

Properties of Silver-Sheathed Multi-Cored Tl-Ba/Sr-Ca-Cu-O Tapes

906C7539dd Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 138

[Artic. by F. Hosono, A. Nomoto, K. Nomura, T. Umezawa, and M. Seido, Hitachi Cable Ltd., T. Matsumoto, Hitachi Ltd.]

[Text] Preface

We previously reported that we were able to obtain a comparatively high critical current density Jc using a multicore silver-sheathed, tape-shaped wire filled with a Tl based superconductor.[1] Here, we report on microscopic structure and the magnetic field dependence of Jc.

Testing Method and Results

A Tl-based superconductor prepared by the powder method was pulverized and put into a silver pipe. Then, it was drawn in a plastic working manner, rolled (or pressed), and processed into the form of tape. Next the superconducting tape was sintered and heated in oxygen at 800 to 900°C. Thus, we prepared 36-core and 1332-core wires. Figure 1 shows the relationship between Jc and tape thickness. The 36-core wire showed a Jc of 8600 A/cm^2 and the 1332-core wire showed a Jc of 1200 A/cm^2. Figure 2 shows the magnetic field dependence of Jc. The figure shows that the lowering of Jc is caused by weak link in a microscopic magnetic field and weak pinning force in the vicinity of 1T. It can be also demonstrated that as Jc in zero magnetic field is improved, Jc in a magnetic field is improved.

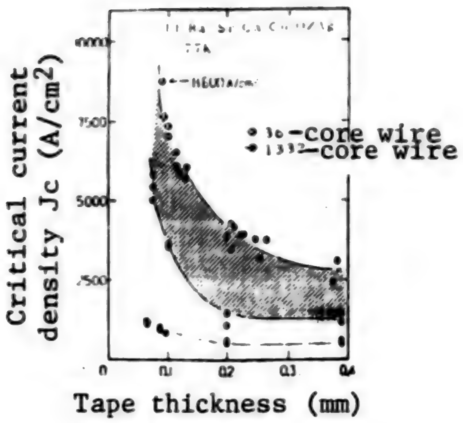


Figure 1. Relation Between Jc and Tape Thickness

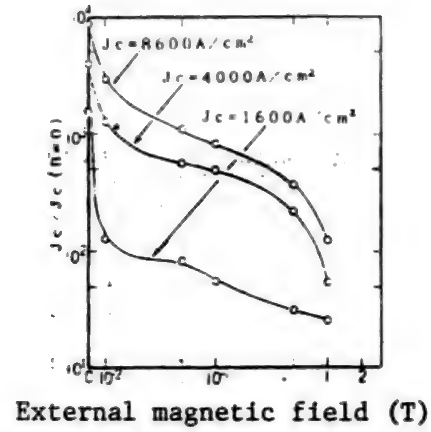


Figure 2. Magnetic Field Dependence of Jc

Reference

1. Hosono, et al., Characteristics of Multicore Tl-Ba/Sr-Ca-Cu-O Silver-Sheathed Tape-Shaped Wire, Applied Physics Society Spring Meeting preliminary report, 1989.

A Simple Method of Fabricating Preferentially Oriented $YBa_2Cu_3O_{7-x}$ Film on Ag Substrate

906C7539ee Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 139

[Article by M. Suzuki, S. Kondoh, E. Yanagisawa, J. Shimoyama, N. Irisawa, and T. Morimoto, Research Center, Asahi Glass, Ltd.]

[Text] We have found a new process to prepare high-Tc superconducting films with a·high critical current density (Jc) on a flexible metal substrate. First, we attempted to join a $YBa_2Cu_3O_{7-x}$ material with Ag, Au, etc. We put a green sheet (thickness: ~30 μm) made of temporarily burned $YBa_2Cu_3O_{7-x}$ powder on an Ag substrate (width: 5 mm, length: 17 mm, and thickness: 0.2 mm) and heated it in oxygen at 920 to 930°C. As a result, a superconducting film, with excellent adhesion qualities with the Ag substrate, was produced. From X-ray diffraction and SEM observations, we have learned that the film produced is a ceramic, porous structure composed of non-oriented $YBa_2Cu_3O_{7-x}$ crystals. Tc, Jc, and contact resistance of the film were about 91K, 1000 A/cm^2, and 10^{-8} Ω (77K), respectively.

Next, in order to improve Jc by preparing fine films, we studied whether sintering by liquid phase inclusion can be carried out on an Ag substrate. It has already been shown that the addition of Cu to $YBa_2Cu_3O_{7-x}$ causes the melting temperature to decline to about 970°C. We, however, have found from DTA that the first liquid phase appears in oxygen at 904°C in the case of the $YBa_2Cu_3O_{7-x}$-CuO-Ag system. Therefore, we plated the surface of the Ag substrate with Cu. Then, we put a green sheet on the plated Ag substrate and sintered it in oxygen at 920 to 930°C. As a result, plate-shaped $YBa_2Cu_3O_{7-x}$ crystals were strongly oriented and a densely layered structure was obtained (Figure 1 [not reproduced]). The Jc and Tc of this film were about 3000 A/cm^2 and 92K, respectively. Thus, an improvement of Jc was clearly observed.

Preparation of Bi(Pb)-Sr-Ca-Cu-O Superconducting Tape by Ag Sheath Method

906C7539ff Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90
p 139

[Article by T. Kitamura, T. Hasegawa, H. Kobayashi, and Y. Kamisada, Showa Electric Wire & Cable Co., Ltd.]

[Text] 1. Preface

The manufacture of wires using oxide superconductors is being carried out using various processes. Of these processes, the Ag sheath process is getting the most attention. However, since sheathed superconductors are multicrystals, such factors as density, particle growth conditions, continuity, impurities, etc. greatly affect the critical current density (Jc) of the superconductors. We paid particular attention to impurities and studied the relationship between the impurity formation condition and Jc.

2. Process

The composition of the raw powder used is $Bi_{0.9}Pb_xSrCaCu_{1.6}O_y$. The raw powder, prepared by the solid phase method, was temporarily burned at 820°C for 24 hours and pulverized. The pulverized powder was put into an Ag pipe which was drawn and rolled. A tape of 0.15 mm in thickness was prepared. This tape was heated at 830° to 850°C for 50 to 400 hours and the characteristics were evaluated.

3. Results

Figures 1 and 2 show the burning time dependence of Jc and impurity rate where the amount of Pb is changed. These figures show that where the amount of Pb is 0.1, the tape shows the highest Jc, though Ca_1CuO_1 can be observed as an impurity. If the amount of Pb is increased, Ca_1CuO_1 decreases, Ca_1PbO_4 appears, and Jc lowers. This indicates that Jc is affected not only by the amount of impurities but also by the types of impurities. In other words, Jc appears to be determined by differences in the degree of presence of these two types of impurities in the sintered material. The results of SEM observation of the above phenomena will be reported at the meeting.

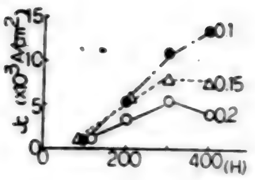


Figure 1. Relation Between Amount of Pb and Jc

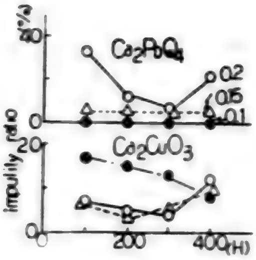


Figure 2. Relation Between Amount of Pb and Impurity

Micro Fabrication of Y-Ba-Cu-O Thin Films by Electron Beam Lithography

906C7539gg Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 160

[Article by H. Enami, T. Shinohara, N. Kawahara, S. Kawabata, and H. Hoshizaki, Nippondenso Co., Ltd., T. Imura, Aichi Institute of Technology]

[Text] 1. Preface

It is an important technology to manufacture superconductor-insulator-superconductor type (hereinafter referred to as "SIS type") Josephson junctions in the basic research and application of oxide superconductors. As the first step to manufacture SIS type Josephson junctions, we attempted the microscopic processing of Y-based superconducting thin films by the electron beam direct exposure method using a transmission electron microscope.

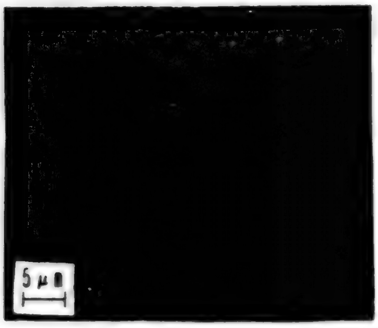
2. Experiments

We formed a c-axis oriented $Y_1Ba_2Cu_3O_{7-x}$ superconducting thin film by RF magnetron sputtering. Then, we formed a bridge of 10 x 10 μm by wet etching, which uses phosphoric acid, and linearly scanned the bridge in a STEM mode using a transmission electron microscope (made by Nippon Electron, JEM-4000EX). Described below are the scanning conditions.

·Acceleration voltage: 400 KV
·Filament current: 130 μA (approximate actual current: 40 μA)
·Beam diameter: 4 nm
·Exposure time: 30 to 60 seconds

3. Results

There was a linear relation between the exposure time and the processed line width. From this, we have learned that the exposure time should be maintained at 30 seconds or less to obtain a line width of 10 nm or smaller. We have also learned that superconducting characteristics deteriorate by electron beams and that microscopic processing can be carried out (see figure below). The deterioration of superconducting characteristics was caused by electron beam annealing. Where the exposure time was extended, recrystallized Y-based superconductor crystals appeared over the entire film.


5 μm

Anisotropic SNS Josephson Junctions Consisting of Y-Ba-Cu-O/Au/Nb Film Sandwiches

906C7539hh Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90 p 163

[Article by H. Akoh, S. Kohijiro, and S. Takada, ETL, C. Camerlingo, CNR]

[Text] With respect to oxide superconducting devices with a thin film layered structure, it is very important to control the surface superconductivity and interface characteristics of oxide superconductors whose coherent length is short and anisotropic. Here, we report on the anisotropic characteristics of a layered SNS Josephson junction (Y-Ba-Cu-O/Au/Nb) which uses a Y-Ba-Cu-O film with a different orientation.

As-grown Y-Ba-Cu-O superconducting thin films used for SNS junction were prepared by reactive simultaneous vacuum evaporation. C-axis and a-b surface oriented films were epitaxially grown on an (100)MgO substrate and a (110)SrTiO3 substrate, respectively. Tc was 70 to 80K.

When SNS junctions using c-axis oriented Y-Ba-Cu-O films were used, no Josephson current was observed, though the Au barrier thickness was changed by 5-50 nm. This is because the coherent length of the c-axis oriented films is short and sufficient proximity effects cannot be obtained at the junction interface between Y-Ba-Cu-O and Au.

Figure 1 shows a schematic configuration of SNS junctions that use a-b face oriented Y-Ba-Cu-O films. We prepared two types of SNS junctions: one in which the Cu-O face is vertical to the junction direction (junction J1); and one in which the Cu-O face is parallel to the junction direction (junction J2). The Au barrier thickness was 15 nm. Microwaves were irradiated to both junctions J1 and J2 and a shapiro step was observed. These junctions, therefore, were confirmed to be Josephson junctions. Figure 2 shows the magnetic field dependence of Josephson critical current Ic for junctions J1 and J2. The figure shows that different Cu-O face orientations cause the magnetic field dependence of Ic to vary greatly. The difference in the magnetic field dependence of Ic appears to be caused by the anisotropy of the Y-Ba-Cu-O film magnetic field penetration length with regard to external magnetic field.

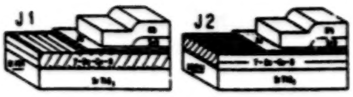


Figure 1. Schematic Configuration of SNS Junctions

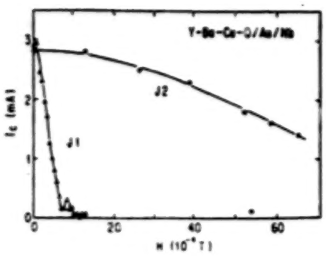


Figure 2. Magnetic Field Dependence of Ic

Fabrication of SNS-Type Josephson Junction Using BSCCO Single Crystal

906C7539ii Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese 28 Mar 90
p 163

[Article by G. Matsubara, T. Nishikawa, and Y. Okabe, Faculty of Eng., University of Tokyo, S. Kishida, K. Nishimori, and H. Tokutaka, Faculty of Eng., Tottori University, T. Matsui, Fuji Electric Co., R&D]

[Text] Where Josephson junctions are prepared using oxide high Tc superconductors, generally produced thin films involve surface roughness, chemical metamorphosis, precipitation and adsorption of impurities, etc. This makes it difficult to obtain reproducible results. Therefore, we conducted chemical passivation of a BSCCO surface and formation of an N layer by vacuum evaporating Au on the clean surface obtained by cleaving the surface vertical to the c-axis, with respect to 80K phase Bi-Sr-Ca-Cu-O single crystals prepared by the self-flux process. Then, we vacuum evaporated in-situ Pb as the upper superconducting electrode and thus prepared an SNS Josephson junction. Figure 1 shows differential resistance characteristics (dV/dI-V) where the Au and Pb film thicknesses were determined to be 10 nm and 200 nm, respectively. Further, the size of the junction was determined to be 1 mm x 5 mm.

A series of experiments conducted to change the Au film thickness from 0 to 50 nm has revealed that where Pb comes into direct contact with BSCCO, a layer showing a semiconductor-like resistance change is inserted into the interface between Pb and BSCCO and that abnormal resistance shown in Figure 2 is observed. Further, where the Au film thickness was determined to be 10 nm or smaller, a superconducting current was observed. Where the Au film thickness was determined to be 5 nm, only Ic changed when microwaves of 10 GHz were applied to the film, and the junction showed a definite response.

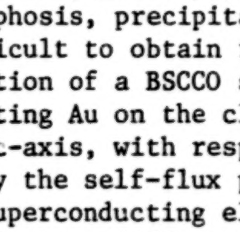


Figure 1

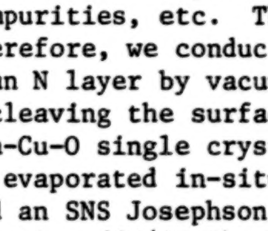


Figure 2

Effect of Li Addition to Bi-Sr-Ca-Cu-O Thin Films

906C7539jj Tokyo OYO BUTSURIGAKU KANKEI RENGO KOENKAI in Japanese Mar 90 p 170

[Article by Y. Egami and M. Kinugasa, Tayca Co., Ltd., H. Tabata, Kawasaki Heavy Industry, T. Kawai and S. Kawai, Osaka University]

[Text] It is reported that the addition of Li to a $Bi_2Sr_2Ca_1Cu_2O_y$ superconducting bulk makes it possible to improve Tc and to crystallize 80K phases at low temperatures.[1] We used the process in which beams are condensed as an ArF excimer laser (193 nm) being a target and a film is formed on the opposite MgO substrate at room temperature, in order to prepare a BSCCO thin film, to which Li was added. The table below describes the Li added bulk (used as a target to prepare thin films) 80K phase formation burning temperatures and the 80K phase formation annealing temperatures of the thin film prepared at room temperature using the target, according to Li addition rate. As the Li addition rate increases, the 80K phase is crystallized at low temperatures irrespective of whether it is bulk or thin film. Further, the thin film showed a Tc_{on} of 80K when Li was not added but showed a maximum of 95K when Li was added. Thus, it is possible to improve the superconductivity of thin films and to carry out crystallization at low temperatures by adding Li. The results of measurement of thin film properties such as relations between Li addition rate and Tc will be reported.

Bulk Burning Temperature and Thin Film Annealing Temperature According to Li Addition Rate

$Bi_{2.0}Sr_{2.0}Ca_{1.0}Cu_{2-x}Li_xO_y$

	Bulk burning temperature	Thin film annealing temperature
X = 0.00	850	830
X = 0.50	780	785
X = 0.75	750	780
X = 1.00	740	775
X = 1.50	730	770

Reference

1. Physica C, 161, (1989), 561.

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